Food Irradiation

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History of the Irradiation Preservation of Food

Early in the 1920s, a French scientist discovered that irradiation could be used to preserve food. This technology was not adopted in the U.S. until World War II. At this time there was a need to feed millions of men and women in uniform. The U.S. Army sponsored a series of experiments with fruits, vegetables, dairy products, fish and meats.

Year	Food	Dose	Purpose
1963	Wheat flour	0.2-0.5 kGy	Control of mold
1964	White potatoes	0.05-0.15 kGy	Inhibit sprouting
1986	Pork	0.3-1.0 kGy	Kill Trichina parasites
1986	Fruit and vegetables	1.0 kGy	Insect control, extend shelf life
1986	Herbs and spices	30 kGy	Sterilization
1990- FDA	Poultry	3 kGy	Bacterial pathogen reduction
1992-USDA	Poultry	1.5-3.0 kGy	Bacterial pathogen reduction
1997-FDA USDA-٢٠٠٠	Meat	4.5 kGy	Bacterial pathogen reduction
2000 - FDA	Shell eggs	3 kGy	Bacterial pathogen reduction

What is the irradiation process?

The irradiation process involves exposing food to intense controlled amounts of ionizing radiation˙ "gamma rays" from cobalt-60 or cesium-137 "x-rays" or "electron beams" from particle accelerators.

The process has about the same effect on food as canning, cooking, or freezing. It kills pests and extends shelf life.

Exposing materials, including foods, to radiation from an irradiator is very different from exposing them to radiation from a reactor. The gamma radiation from cobalt-60 in an irradiator kills bacteria and germs, but does not leave any radioactive residue or cause any of the exposed materials to become radioactive. The cobalt-60 in an irradiator is contained in stainless steel capsules and does not commingle with the material being irradiated.

On the other hand, material exposed to neutrons from a reactor or linear accelerator can become radioactive.

Why does food irradiated?

With some foods, even the best sanitation and standard antibacterial treatments cannot ensure safety. For example, there is no guarantee that raw ground beef or raw sprouts will be free of certain harmful bacteria. These foods provide a favorable environment for bacterial growth and their production process does not include a “kill step,” such as cooking or pasteurization.

For these foods, irradiation provides a “bacteria-killing” step without cooking the food.

Foods may also be irradiated to extend shelf life, and imported fruits and vegetables may be irradiated to kill insect pests that might otherwise threaten agriculture.

Does irradiated food need to be cooked?

Irradiation is a cold process that leaves the food fresh, so you can cook it just as you would any other food. While irradiation virtually eliminates harmful bacteria, the food is not made sterile.

Are irradiated foods sterile?

No. only a low level of irradiation is used to eliminate harmful bacteria in meat and poultry products, similar to pasteurizing milk. Because common spoilage bacteria are still present, irradiated food must still be stored and handled properly.

Irradiation pasteurizes food by using energy, is similar to pasteurizing milk using heat. In this process harmful bacteria will be destroyed thus making our food safer, but not sterile. The level of energy used does not kill certain spoilage organisms providing a further protection for consumers. As with non-irradiated foods, spoilage bacteria will multiply if the food is not properly handled and alert consumers not to use this particular food product.

Food can be sterilized at higher irradiation doses, but other than spices, these are not commercially available. Irradiated food eaten by astronauts has been treated at high doses to make it sterile. Not all foods are suitable for radiation sterilization.

Do irradiated foods require special packaging?

The FDA must approve packaging in contact with the food during the irradiation process. Many common materials such as polyethylene film, paper and cardboard have already been approved. Generally irradiated products do not require any special packaging, from a physical point of view. However, packaging that is in contact with the food during irradiation must be approved by the FDA

Current packaging materials that are approved include polyethylene film, white polystyrene trays, certain nylons and PET.

Packaging producers are working with their customers and the FDA to obtain approval for other materials in the near future.

How should irradiated food be handled?

Proper handling procedures are still necessary for processors. Meat and poultry should be kept refrigerated. Contact surfaces, preparation implements and the cook hands must be cleaned to prevent cross contamination. Consumers, stores and restaurants should follow the same careful handling and preparation procedures whether the food is irradiated or not.

Also many enzymes survive the current levels of radiation processing, although refrigeration can slow down many enzymatic changes. In addition, not all microorganisms are destroyed. The process does not protect the food against reinfection or contamination. Therefore, irradiated perishable foods are still considered perishable.

How does irradiation destroy bacteria?

Irradiation of any biological system, such as a bacterial cell, with ionizing energy leads to a portion of the incident energy being absorbed at random sites within the material of the biological system. At these sites the energy activates the absorbing molecules and gives rise to primary reactive species including ions, free radicals and excited molecules.

These activated molecules have the ability to initiate chemical reactions with other molecules present in the system. The reactive species diffuse out of the sites of their formation and chemically attack various other biomolecules, including nucleic acids (DNA, RNA), membrane lipids, proteins, carbohydrates and others, causing damage to them .

If the molecules which have been damaged ordinarily play a critical role in cell function, then in their damaged form their ability to perform this vital function is lost, and the cell can no longer proliferate. Although the damage inflicted via the reaction cascade initiated by the primary reactive species afflicts all the major classes of biomolecules, scientific consensus is that cell killing is primarily due to damage to the DNA of the cell.

Doses and effects of Radiation

The "dose" for food irradiation is the amount of radiation absorbed by the food and it is not the same as the level of energy transmitted from the radiation sources. The dose is controlled by the intensity of radiation and the length of time the food is exposed.

Terms used to describe this "dose" or amount of absorbed radiation, are unfamiliar and confusing to most people. In the past, the term used was rad, short for "radiation absorbed dose," which is 100 ergs absorbed by 1 gram of matter. The rad has been replaced by the gray (Gy). One gray is equal to 100 rads or 0.00024 Calorie per kilogram of food The FDA's regulations describe radiation levels in terms of the kilogray (kGy), equal to 1000 Gy.

The dose permitted varies according to the type of food and the desired action. Treatment levels have been approved by FDA as follows:

- "Low" doses - (up to 1 kGy) designed to

1. control insects in grains
2. inhibit sprouting in white potatoes
3. control trichinae in pork
4. inhibit decay and control insects in fruits and vegetables

- "Medium" doses - (1-10 kGy) designed to
  1. control *Salmonella*, *Shigella*, *Campylobacter*, *Yersinia* and *E. Coli* in meat, poultry and fish
  2. delay mold growth on strawberries and other fruits
- "High" doses - (greater than 10 kGy) designed to
  1. kill microorganisms and insects in spices
  2. commercially sterilize foods, destroying all microorganisms of public health concern (i.e. to sterilize food to the same degree as if they were thermally sterilized)

When radiation energy is absorbed by food, it causes a variety of chemical and physical reactions. The amount of energy the food absorbs is controlled so the changes produced have desirable food preservation effects while maintaining the safety, quality, and wholesomeness of the food.

Does irradiation make food radioactive?

No. As food is passed through the irradiation field, energy passes through the food much like a ray of light passes through a window. This energy destroys most of the bacteria that can cause disease, yet allows food to retain its high quality. Since the energy involved in irradiation is not strong enough to change the atoms of the food,

and since the food is never in contact with a radioactive source, the food can not become radioactive.

What chemical changes occur in food when it is irradiated?

Ionizing radiation leads to a portion of the incident energy being absorbed at random sites within the material. At these sites the energy activates the absorbing molecules and gives rise to primary reactive species including ions, free radicals and excited molecules. These activated molecules have the ability to initiate chemical reactions with other molecules present in the system to produce minor chemical changes in the treated food

The end result of these reactions is tiny amounts of certain chemicals, such as hydrogen peroxide,

Are irradiated foods less nutritious than other foods?

Irradiation has no significant effect on proteins, carbohydrates, fats, trace elements and minerals, such as calcium, iron, and potassium.

However it can reduce the levels of vitamins, including E,C,A and K and thiamin.

Irradiation can lower vitamin E levels by 25 percent. .One Japanese study showed that a typical dose reduces the vitamin C content in potatoes by almost 50 percent. In citrus fruits, less than 10 percent of the vitamin C is depleted,

Before approving the use of irradiation for a particular food, the FDA carefully considers any vitamin loss.

The FDA considers what vitamins would be lost as a result of irradiation and what effect that loss would have on a person's total diet. For each approved use, the FDA must determine that vitamin loss from irradiation would not have a significant impact.

How does irradiation affect the taste of food?

Food properly irradiated according to a validated protocol shows little change in taste. Most people can't detect it.

Any preparation process, be it cooking, baking or irradiation, can affect the taste of food if the process is not properly applied. For this reason foods are generally processed according to a proven recipe or protocol.

This is true also for irradiation processing, and a taste test serves as one of the major criteria guiding the development of a treatment protocol for any particular food. Food manufacturers obviously will not use any process that changes the quality of the food to such an extent that it becomes unacceptable to consumers. There are many good examples of the excellent sensory quality of radiation processed foods, including the NASA menu items, which have been consumed by astronauts for many years.

How many foods are being irradiated today?

Most foods are not irradiated. This may be changing, however, as more and more food processors adopt irradiation to eliminate harmful bacteria that may slip through their other safety procedures.

Some irradiated foods have been eaten in the U.S. and other countries for many years. In the U.S. and several other countries, a significant percentage of spices are irradiated.

- Most of tropical fruits shipped to the mainland U.S. from Hawaii are irradiated.
- A number of hospitals in the U.S. and England use irradiation to sterilize foods for patients with weakened immune systems
- NASA astronauts eat irradiated foods during space missions.

Could irradiation being used instead of good sanitation practices?

No. Irradiation could not, and should not be, a substitute for good sanitation. If a food is too__heavily contaminated, irradiation will not be effective. Just as milk must meet certain sanitation standards before it can be pasteurized, so must foods meet sanitation standards before they can be irradiated.

How does irradiation fit with HACCP?

Irradiation and HACCP are complementary weapons in the battle to ensure the safety of our food supply. HACCP is a plan, which identifies the hazards associated with each food item and determines how each hazard can be reduced or eliminated. Actual control of each identified hazard must then be accomplished by means of at least one ,roadblock or ,critical control point (CCP) put in place at some point along the path between the farm and the consumer, to eliminate bacterial hazards.

Irradiation is a technological intervention that can serve as a highly effective critical control point within the HACCP plan. Planning alone cannot prevent microbial hazards from reaching the consumer; real intervention is required which actually kills the contaminating microorganisms.

International Approval of Food Irradiation:

Alongside traditional methods of processing and preserving food, the technology of food irradiation is gaining more and more attention around the world. In at least 39 countries, health and safety authorities have approved irradiation of more than 40 different foods. These approvals include spices, grains, chicken, fruits, and vegetables.

Twenty-nine of these countries were using food irradiation as a process for commercial purposes. Decisions in other countries have been influenced by the adoption in 1983 of a worldwide standard covering irradiated foods.

This standard was adopted by the Codex Alimentarius Commission, a joint body of the Food and Agriculture Organization of the United Nations (FAO), food and drug administration (FDA), and World Health Organization (WHO) representing more than 130 countries.

It is based on the findings of a Joint Expert Committee on Food Irradiation (JECFI) convened by the FAO, WHO, and International Atomic Energy Agency (IAEA). JECFI evaluated available data in 1969, 1976, and 1980. In 1980 it concluded that “the irradiation of any food commodity” up to an overall average dose of 10 kilogray “presents no toxicological hazard” and requires no further testing. It further stated that irradiation up to 10 kilogray “introduced no special nutritional or microbiological problems” in foods.

How can I tell if food has been irradiated?

You cannot tell by the taste or appearance, federal regulations require that all irradiated foods be labeled and carry a symbol called the radura . Foods that contain irradiated spices or foods served in restaurants do not have to be identified as being irradiated.

With sophisticated analytical tests it is possible to determine if food has been irradiated, e.g. by means of electron spin resonance, and free fatty acid analysis.

Radura logo

Must irradiated food be labeled?

Labeling has been mandatory since 1966;the radura logo was mandated in 1986.The statements “Treated With Radiation ” or “Treated by Irradiation ” must be prominently placed on packages at the retail and wholesale levels.Labeling at the wholesale level must also include the warning not to irradiate the product again.

For unpackaged fruits and vegetables,the retailer must either:

- . Label each individual item.
- . Place a sign next to the commodity displaying the required logo and label to the customer.
- . Use the labeling of the bulk container to inform customers that the foods have been irradiated.

What are the principal safety concerns cited by opponents?

Many are concerned that widespread use of irradiation could prompt producers,distributors and consumers to be less aggressive in practicing other sanitation measures.Some believe that the research on safety issues is inadequate and inconclusive.The major safety issues:

Radiolytic Products — Some of the gamma rays in irradiation break chemical bonds to form short-lived,unstable molecules called free radicals. Some of these then combine with each other and other food molecules to create molecules called “radiolytic products.” Irradiating meat can produce benzene, for example, and irradiating carbohydrate-rich foods can yield formaldehyde. At the prescribed dosage levels, irradiation produces small amounts of such compounds

Among the radiolytic products may be “unique ” compounds that may cause adverse health effects.

Destruction of the “Smell Test ” — Irradiation may reduce bacteria that provide consumers with an odor indicator of spoilage.Food scientists believe that irradiation at the low doses prescribed will not eliminate all odor-causing spoilage bacteria,preserving the smell test.This effect may depend on the dose,temperature,packaging and product.Consequently,FDA is investigating this issue on a case-by-case basis.

Declines in Fecundity (number of offspring)— Research has yielded mixed results.One study showed a significant reduction in the offspring of fruit flies (*Drosophila* melanogaster)fed gamma-irradiated chicken.Tests on beagles showed a higher rate of healthy offspring among the pregnant females fed irradiated chicken.In another test only mice fed cooked chicken showed a decrease in offspring.FDA has concluded that none of these studies demonstrated an irradiation-related effect.

Aflatoxin — Certain molds produce these naturally occurring carcinogens,especially in grain.One study suggested that aflatoxins grow better on irradiated grain because the treatment destroyed competing microorganisms.Aflatoxin growth will not occur,researchers say,when grain is treated with a dose high enough to kill all microorganisms on grain that is subsequently kept isolated from further contamination.Most foods can be prepackaged before being irradiated,reducing the risk of recontamination.

Opponents and supporters agree that irradiation should not be viewed as a substitute for safe sanitation practices.Irradiated foods can be re-contaminated if they come into contact with unclean surfaces or raw foods,or if they are otherwise improperly stored,handled or prepared.

Radiation as a tool in Agriculture research

Radiation has become an increasingly important tool in agricultural research and practice. Some uses and their benefits are:

-Radioisotopes as a research tool help develop new strains of food crops that are more nutritious, resist disease, and produce higher yields. For example, radiation has been used in producing peanuts, tomatoes, onions, soybeans, barley, and the "miracle" rice that has boosted rice production in Asia.

-Radioisotope tracers in plant nutrients aid in reducing soil and water pollution by helping researchers to learn how plants absorb fertilizer and how to calculate the optimum amount and frequency of fertilizer applications.

-Moisture monitoring with nuclear density gauges can measure the moisture content of soil, helping make the most efficient use of limited water sources for successful crop production.

-Insect sterilization with radiation results in mating without offspring, thus limiting insect population growth. This has eliminated screwworm infestation in the southeastern United States and Mexico, and has helped control the Mediterranean fruit fly in California. With fewer pests, food crop productivity increases.

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